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ORIGINAL PAPER

Population dynamics of some coccids (Coccoidea: Hemiptera) infesting sandal (*Santalum album* Linn.) in Bangalore, India

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Abstract: A study was conducted to investigate the population dynamics of four important coccids viz., *Aonidiella orientalis* (Newstead), *Ceroplastes actiniformis* Green, *Cardiococcus bivalvata* (Green) and *Parasaissetia nigra* (Nietner) infesting sandal in Bangalore, India. Meteorological data *viz.*, monthly mean maximum and minimum temperatures, morning and evening relative humidity and total rainfall were also collected during the experimental period for statistical analysis to ascertain their influence on the population of coccids. The results show that all the four coccids are infesting sandal throughout the year. Maximum temperature exhibited significantly negative correlation with the population dynamics of *A. orientalis*, while other weather parameters did not show much influence on its incidence. In case of *C. bivalvata*, minimum temperature and morning relative humidity exhibited significant positive correlation with its population dynamics while other weather parameters had less significant effect on its population dynamics. For *C. actiniformis* and *P. nigra*, none of the weather factors seem to have influence on their incidences.

Keywords: *Aonidiella orientalis*; *Ceroplastes actiniformis*; *Cardiococcus bivalvata*; *Parasaissetia nigra*

Introduction

Indian sandalwood (*Santalum album* Linn.), acknowledged as "Royal Tree" in Indian subcontinent, has gained importance mainly for its scented heartwood that yields essential oil, commercially known as "East Indian Sandal Wood Oil". Its oil, alone has significantly contributed to revenue of around Rs. 160 million through the export of almost 27 tons of oil per year. The world market demand of sandalwood is around 5 000–6 000 tons in which more than two-third is for Indian sandalwood. Currently, output of sandalwood has shown a steep decline in India and market prices of sandalwood and oil have increased to the level of Rs. 1.2 millions per ton and Rs. 75 000 per kilogram, respectively. This steep increase in price is mainly due to large gap between demand and supply (Venkatesha Gowda et al. 2008). To bridge this gap, a large-scale sandal plantation program is a necessity. Moreover, with the relaxation of restrictions made by the government to the public to grow sandal for the commercial purpose, a rapid expansion of sandal acreage in India has recently been observed. Among the various factors, insect pests are one of the most important factors limiting the successful establishment of sandal plantations. Among the insect pests, scale insects and mealy bugs, which are commonly referred as coccids or coccoids (Varshney 1992), are detrimental for many plants (Ayyar 1929). Indian sandal wood has been found to be infested by 23 species of coccids, which are the potential pests in nurseries and plantations (Sundararaj et al. 2006). Twig die-back or premature loss of leaves is a common symptom of attacked sandal (Varshney 1992, 2002; Remadevi & Muthukrishnan 1998). This resulted in withering of flowers along with drying and premature falling of fruits (Sivaramakrishnan et al. 1987). Studies revealed that the attack of these coccids can be harmful and even fatal to the sandal tree. The waxy secretions of these coccids are quite resistant to insecticidal penetration and, therefore, a holistic approach for their management is very essential to increase the production of sandalwood. Four coccids viz *Aonidiella orientalis* (Newstead), *Ceroplastes actiniformis* Green, *Cardiococcus bivalvata* (Green) and *Parasaissetia nigra* (Nietner) were found to infest sandal in Bangalore, throughout the year. The aim of the present study is to assess their population dynamics in infesting sandal in Bangalore, India.

Materials and methods

The study of population dynamics was conducted from April

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2004 to March 2006 in Bangalore on provenances of sandal which is maintained naturally without any spraying/irrigation in the campus of Institute of Wood Science & Technology, Bangalore in an area of one hectare. It is located in 12°58'N 77°38'E at altitude of 1000 m in south India. Soil type is red loam and acidic (pH 6.3 to 6.5). The annual mean maximum and minimum temperatures are 36.8 °C and 12.2 °C, respectively, and annual precipitation is 850 mm. For assessing the population dynamics of coccids, five blocks of 17 × 17 m in the size were marked. Ten sandal trees of 3 to 4 years old were selected at random in each block. On each plant, number of nymphs of coccids viz., *A. orientalis*, *C. actiniformis*, *C. bivalvata* and *P. nigra* were recorded from five randomly selected twigs of 30-cm length in each direction. The observations were made at monthly intervals. The data thus collected were pooled and mean was computed for statistical analysis. Meteorological data *viz.*, monthly mean maximum and minimum temperatures, morning and evening relative humidity and total rainfall were also collected during the experimental period for statistical analysis. Correlation and multiple regression analysis were carried out separately for each factor by following the method (Fisher and Yates 1938).

Results and discussion

Aonidiella orientalis

Incidence of *Aonidiella orientalis* was noticed throughout year with peak incidence from November to January (Fig. 1). *Aonidiella orientalis* attacks mainly young leaves of *Santalum album* Linn. Monthly mean maximum temperature exhibited significantly negative correlation with its population (-0.558), while other weather parameters did not show significant influence on its incidence (Table 1).

Table 1. Correlation and regression equation of the population of coccids with weather factors

Weather factors	Correlation coefficient for different species			
	Aonidiella orientalis	*Ceroplastes actiniformis*	*Cardiococcus bivalvata*	*Parasaissetia nigra*
Maximum temperature	-0.558*	0.001	0.325	-0.153
Minimum temperature	0.473	0.151	0.552*	-0.022
Morning relative Humidity	0.301	-0.008	0.528*	0.172
Evening relative Humidity	0.155	0.1725	-0.021	0.123
Rainfall	-0.094	0.0764	0.321	-0.225
Regression Equation	Y=18.89-0.256 T_{Max}+0.060 T_{Min} 0.043-0.144 RHII +0.053 R_F	Y=18.89-0.247 T_{Max}+0.060 T_{Min} 0.042-0.144 R_{HII} +0.053 R_F	Y=130.39+0.058 T_{Max}-0.263 T_{Min} 1.533+0.527 R_{HII} -0.011 R_F	Y=1.247-0.189 T_{Max}+0.149 T_{Min} 0.046-0.021 R_{HII} -0.012 R_F

Notes: Symbol (*) is significant at 0.05 levels; T_{Max} is monthly mean max. temperature; T_{Min} is monthly mean min. temperature, R_F is Rainfall, R_{HII} is evening relative humidity.

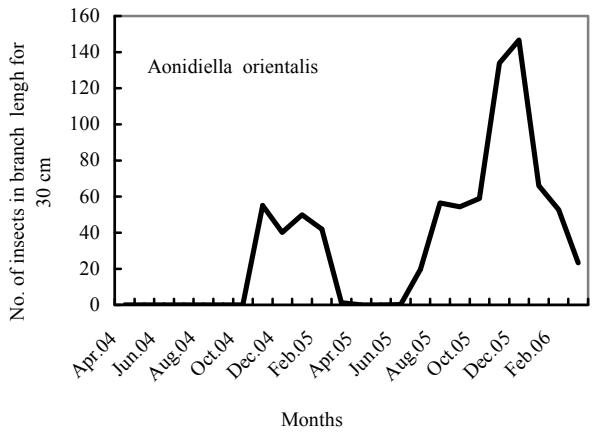

Fig. 1 Population dynamics of *Aonidiella orientalis* during 2004-2006

Cardiococcus bivalvata

Its infestation was noticed through out the year with two peaks, one major peak from August to October and one minor peak from March to April (Fig. 2). Monthly mean minimum temperature (0.552) and morning relative humidity (0.558) exhibited significantly positive correlation with the population while other weather parameters had less significant effect on its population (Table 1).

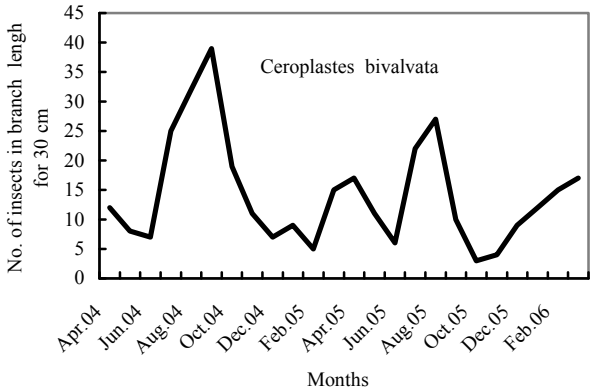

Fig. 2 Population dynamics of *Ceroplastes bivalvata* during 2004-2006

Ceroplastes actiniformis

Incidence of *Ceroplastes actiniformis* was steady throughout the year 2004–2005 but a small peak was observed in March 2006

(Fig. 3). For this pest, none of the weather parameters seemed to have influence on its incidence (Table 1).

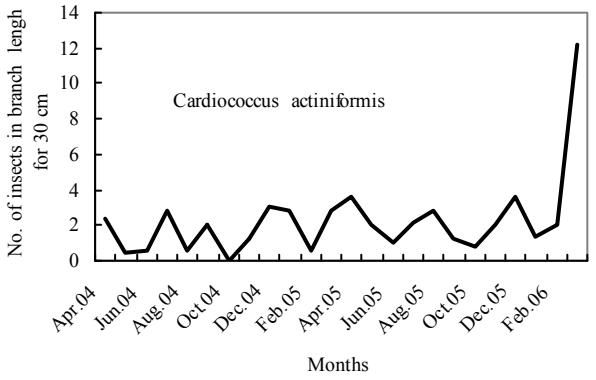

Fig. 3 Population dynamics of *Cardiococcus actiniformis* during 2004-2006

Parasaissetia nigra

This pest persists through out the year with two major peaks from June to July and September to November (Fig. 4). For this pest, none of the weather parameters showed significant influence on its incidence (Table 1).

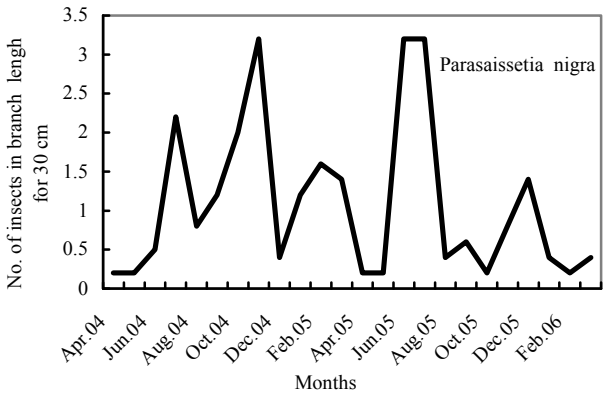

Fig. 4 Population dynamics of *Parasaissetia nigra* during 2004-2006

In the present study, all the assessed coccids were found to infest sandal throughout the year and the different weather factors influenced differently on their populations. The population of *A. orientalis* was significantly negatively correlated with the maximum temperature. *C. bivalvata* exhibited non significant positive correlation with maximum temperature while it had significantly positive correlation with minimum temperature and morning relative humidity. For *C. actiniformis* and *P. nigra*, the weather factors did not seem to have influence on their incidences. The seasonal activities of scales and mealybugs in relation to weather factors were earlier reported by many authors (Ali 1964, Chatterjee and Datta 1974; Mani 1993; Mani et al. 1990; Mani and Krishnamoorthy 2002). Since the weather parameters did not show any significant relationship with population fluctuation of *C. actiniformis*,and *P. nigra* their population fluctuation might be attributed to the activity of the predators and parasitoids in the study areas. It is in conformity with the report of Mani and Krishnamoorthy (2002) who reported that predators and parasitoids play a major role in regulating the population of coccids.

Among the coccids, *A. orientalis* was found to be parasitized only by an aphelinid *Aphytis* sp.. *C. bivalvata* was found to be parasitized by two aphelinids (*Coccophagus bivittatus* Compere and *Marietta leopardina* Motschulsky), two encyrtids (*Anicetus inglisiae* Hayat and *Microterys agaeus* Hayat) and an eulophid *Aprostocetus* sp. More number of parasitoids were found on *C. actiniformis*, which includes two aphelinids viz., *Coccophagus cowperi* Girrault and *C. ceroplastae* (Howard), four encyrtids viz., *Bothriophryne pulvinariae* Agarwal, Agawarwal & Khan, *Cheiloneurus basiri* Hayat, Alam & Agarwal, *Encyrtus aurantii* Geoffroy, and *Metaphycus bolangerae* Hayat. *P. nigra* was found to be parasitized only by a pteromalid parasitoid (*Scutellista cyanea* Motsch). Among the predators, coccinellids (Coleoptera) were dominant with 15 species viz., *Anegleis cardoni* (Ws.), *A. perrotti* (Mulsant), *Brumus suturalis* Fabricius, *Cheilomenes sexmaculata* (Fabr.), *Chilocorus nigrita* (Fabr.), *Coccinella septumpunctata* Linn., *Cryptolaemus montruizeri* Mls., *Cybocephalus indicus* Tian & Ramani, *Harmonia octomaculata* (Fabr.), *Illeis cincta* (Fabr.), *Nephus regularis* Sic., *Pseudaspidemerus circumflexa* Motsch, *Pullus coccidivora* Ayyar, *P. gratiosus* Wse. and *Scymnus* sp. The other predators include three species of chrysopids (Neuroptera) viz., *Chrysopa* sp., *Chrysoperla cornea* (Stephans) and *Mallada boninensis* (Okamato) and a species of lycaenid (Lepidoptera) *Spalgis epius* (Westw.). Hodek and Honeˇk (2009) reported that coccids were essential food for a large proportion (36%) of coccinellid species globally, especially in the tropics and subtropics. The study enlightened to have a holistic approach for the better management of economically important coccids by using potential natural enemies (particularly coccinellids) to increase the production of sandalwood.

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